Wakeful positioning and movement control in young infants: A pilot study

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Purpose: Clinical experience has suggested differences in motor development between infants nursed prone, and those nursed supine. This pilot study investigated possible associations between wakeful infant positioning and motor control. Method: Twenty-six infants were examined. Wakeful positional experience was recorded by log book. When the infants were aged between 14 and 18 weeks, motor control was measured using five items from the Movement Assessment of Infants. Results: Analyses revealed associations between age and time spent in stimulating circumstances, and some motor scores, but not an association between time spent in prone and supine positions and motor skills in those positions. Conclusion: Time spent in positions involving greater stimulation from, and closer interaction with, caregivers may be beneficial to motor development in early infancy. **[Bridgewater KJ and Sullivan MJ (1999): Wakeful positioning and movement control in young infants: A pilot study. *Australian Journal of Physiotherapy* 45: 259-266]**

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Introduction

Differences in rates of infant motor development are extensively documented (Cratty 1986, Horowitz and Sharby 1988), and widely accepted by professionals working with children. There may be many causes for such differences in patterns and rates of development. Much research has been dedicated to the effects on child development of various intra- and extra-uterine factors such as drugs, stress, nutrition, socio-economic status, race, parental age, pre- and post-maturity and multiple pregnancy (Cratty 1986, Illingworth 1987).

It is recognised that behaviour is affected by environment and the infant's responses to that environment. However, the precise effects of differing physiological and environmental factors on the motor development of full-term infants remain relatively unknown. The impact of sleeping positioning on infant motor development has recently been examined (Davis et al 1998). Evidence also exists that habitual positioning in adults is intimately related to musculoskeletal function and postural control (Kendal and McCreary 1983, Norkin and Levangie 1983), a phenomenon more recently investigated in infants (Douret 1993).

Clinical experience of physiotherapists has long suggested subtle differences in the sequence of development of movement control when comparing infants with prone position experience and those habitually positioned in supine (Horowitz and Sharby 1988). Despite a paucity of evidence supporting the clinical observation (Douret 1993), such impressions influence the responses of infant health workers when asked by parents to specify positions most conducive to infant motor development.

The emotional and social environments in which an infant is raised are aspects which may be overlooked by researchers considering motor skill acquisition. Emotional deprivation has long been identified as a potential contributor to delays in physical development (Dennis 1935 and 1938). Conversely, it has been proposed that increased physical contact, handling and parental stimulation beneficially influence motor development (Cratty 1986, Parizkova 1984).

A recent trend in nursing advice is to recommend avoidance of the prone position for sleeping infants. This recommendation is in response to literature linking the prone sleeping position with a higher risk of Sudden Infant Death Syndrome (SIDS) (Mitchell et al 1992, Nelson et al 1989, Wigfield et al 1992). However, the public perception appears to be that wakeful prone positioning is also unsafe because of a higher risk of SIDS (Mildred et al 1995). Even though

Table 1. Biological data of the sample of 13 males and 13 females.

	Minimum	Maximum	Mean	Standard deviation
Weight at birth (grams)	2600.0	4100.0	3466.35	418.58
Length at birth (cm)	46.0	52.5	50.65	2.03
Head circumference at birth (cm)	32.5	37.0	34.95	1.28
Gestational age (weeks)	38.0	42.0	40.04	1.22
Adjusted age when assessed (days)	98.0	126.0	112.31	9.73

most authorities advise against a prone sleeping position for infants, prone positioning should not be neglected during wakeful hours, as it may play a role in achieving stability (Horowitz and Sharby 1988). Child rearing practices which are shown to improve prone motor abilities may assist health professionals as they encounter nervous parents' tendencies to avoid the prone position altogether.

The fourth month is recognised as a critical time of child development (Bly 1983, Scherzer and Tscharnuter 1982). As many new skills are acquired at this time, subtle differences in infant development can be ascertained. However most four-month-old infants are not yet able to roll. Accordingly, monitoring wakeful positioning is facilitated by the infant's general inability to roll away from the position chosen by the parent.

The aim of this study was to investigate whether, at four months of age, there is an association between an infant's positional experience during wakeful time, and the maturity of a circumscribed area of motor development, namely head and shoulder girdle control, as assessed by five selected movement assessment techniques.

Method

Subjects The subjects were 26 healthy Caucasian infants (equal numbers of males and females). On the day of movement assessment, subjects' ages were between 14 and 18 weeks, in order to comply with the four-month scoring profile of the Movement Assessment of Infants (MAI) (Chandler et al 1980). Biological data of the sample is provided in Table 1.

The subjects, from backgrounds of varying socio-economic status, were recruited through the Child and Adolescent Family Health Services (CAFHS) of South Australia, and by word of mouth. All subjects were classified "at low risk of developmental delay" in accordance with the protocol of the Women's and Children's Hospital in Adelaide. Subjects were from singleton births, with gestational ages between 38 and 42 weeks. Infants' data at birth for weight, length, and head circumference were between the tenth and ninetieth percentiles for gestational age and gender.

Materials (i) The log book: This comprised a written record of the time at which the subject was moved and the position into which the subject was placed. In this manner, the amount of time spent in each of the positions was recorded. Parents recorded this information during the infant's 12 most wakeful hours, over three consecutive days.

Reliability studies on parents as observers and recorders of their children's behaviour, as documented in journals, were examined (Christopherson et al 1972, Hall et al 1972, Mash and McElwee 1974). Methods suggested to improve accuracy and reliability were incorporated, where possible, into the design of the log book. Six mothers and their four-month-old infants who did not participate in the study proper, participated in trials of evolving the log book. Their feedback was used to minimise the effort required by parents, thereby enhancing accuracy and compliance while logging. In this way, a highly appropriate logging method was created which measured wakeful positioning experience. The importance of keeping the log updated throughout the observation period (rather than in retrospect) was stressed to all observers.

(ii) Selected MAI items: Infant movement responses at four months of age can be scored for quality and maturity by using the a priori normative scoring profile provided by the authors of the MAI (Chandler et al 1980). Five test items were selected from the MAI for use: head centring, hands to midline, head righting (flexion), head righting (extension), and active weight bearing through shoulders. The score that each subject could attain for any of the selected MAI items ranged from 1 (the most mature response), to 4 (the least mature response). The selected items were all included in the four-month scoring profile of Chandler et al (1980), and together represented an assessment of head and upper limb control, which are significant motor milestones at four months of age. Furthermore, items were selected which assessed motor maturity in both prone and supine positions, allowing for subjects having differing skills in those positions. The five items used for the movement assessment had acceptable reliability (Haley 1986, Sullivan 1994).

Procedure The use of the log book was such that each parent was required to record the positions their infant experienced during its most wakeful 12h period. This was done for any three days of the pre-assessment week. These days were accepted as representative of the infant's normal routine. The log book provided a reference list of 10 positions (and codes) frequently used by parents in contemporary Australian society for infants of this age group (B = back, T = tummy, SL = side lying, S = supported sitting, C/C = capsule (semi-supine baby carrier)/cuddle (supine), FL = feeding left breast, FR = feeding right breast, BB = bottle-feeding on back or nursed, SCV = sling or cuddled vertical, O = other). If an infant was asleep in any position, a "Z" was the position code. The tenth position, other, required parents to describe the position. After discussion with each parent, other positions were re-classified as one of the antecedent nine, time in the bath, or exercise time. Exercise was a position classification for periods of time when an infant was being handled in a playful manner and moved through many positions of short duration. No instructions or guidance were provided to parents as to what positions should be encouraged.

Examinations of infants recruited through personal acquaintances were performed at the infant's home. Examinations of infants recruited through CAFHS, were performed at the infant's local CAFHS clinic. It was ensured that all examination rooms were a comfortable temperature and that a suitable table was available. The test surface consisted of a blanket covered by a plastic protective sheet, draped with a cotton sheet. Two portable white slide screens were erected, one on either side of the examination table. The screens ensured that extraneous visual stimuli were excluded, and that all subjects received the same visual stimulation. The researcher performed most of the assessment at one end of the table, and the parent observed from the other end of the table, remaining out of the view of the infant. During the assessment of active weight bearing through shoulders, and head righting (extension), the researcher stood between the table and a screen in order to gain a side view. The assessing researcher was blind to the results of the activity logs.

Prior to the assessment proper, each infant was placed naked in the supine position, on the examination surface for five minutes, allowing the infant to adjust to both the test environment and the freedom of movement obtained by being unclothed. The order of item administration, the number of item repetitions and the timing of each item were standard between infants. The time spent in each position was monitored with a stopwatch; at the end of the time in each position, the researcher recorded the score of the relevant item. All test items were administered in accordance with the directions for testing as specified by Chandler et al (1980).

During a further two minutes in supine, the items head centring and hands to midline were assessed. When scoring the item hands to midline, it was not required that the subject's elbows be raised off the surface.

If, after one minute, an infant had not spontaneously brought hands to midline, and consequently could not score the most mature response, a toy belonging to the infant was introduced. It was presented to the subject in the midline and, if the subject brought hands together, the toy was removed. If the subject either maintained hands in the midline, or attained this position in the time remaining, a score of 2 was awarded. If the infant had not brought hands to the midline while supine, despite the use of a toy, an opportunity to do so was provided in sitting at the end of the testing session, in accordance with Chandler et al (1980). Each infant who required such an opportunity was placed on its mother's knees and supported as low on the trunk as possible for safety.

The two minutes in supine was followed by two assessments of pull-to-sit, the method of assessment for head righting (flexion). All infants were raised by their forearms and scored according to the better of the two performances. Each subject was then placed prone for one minute, during which time the items head righting (extension) and active weight bearing through shoulders were observed and scored. All infants were initially placed with the arms away from the sides of their body.

Data management The item raw score is the score for an infant's movement response for each MAI item (Chandler et al 1980). The item raw scores are shown in Table 2. The total score is the sum of the five item raw scores, calculated for each infant. It is assumed that the total score is a qualified indication of the infant's maturity of upper limb, trunk, and head control. Lower scores equate with relative motor maturity, higher scores with relative motor immaturity. The potential explanatory variates (PEVs) are the infants' ages at the time of assessment, and the amount of waking time spent in each specified position.

Statistics The association between the infants, their positional experiences as documented in the log books and motor maturity scores, were examined through multiple regression.

The total scores were regressed on the 12 PEVs (age, and wakeful time spent in the 11 positions). The coefficients (b_0) for the three feeding classifications were similar, and were combined to create one category, feed. The regression analysis which followed involved the total scores and the 10 resulting PEVs. The results of this analysis were highly significant ($F_{(10,15)} = 4.39$, $p < 0.01$). As many coefficients were nonsignificant ($p > 0.05$), stepwise backward elimination was conducted.

The item raw scores for each selected MAI item were regressed on the same 12 PEVs as the total score. This allowed examination of the interaction of each PEV on each individual motor skill. Once again stepwise backward elimination was carried out, due to the large number of non-significant coefficients.

All reported results are those obtained following stepwise backward elimination unless otherwise indicated.

Table 2. Raw data: Item raw scores and total scores

Subject Number	Scores: HTM	HC	HRF	HRE	AWBTS	TOTAL
1	2	1	3	3	3	12
2	2	1	3	1	1	8
3	3	1	2	2	1	9
4	2	1	1	1	1	6
5	2	1	2	1	1	7
6	2	1	2	1	1	7
7	4	1	2	3	2	12
8	1	1	2	1	1	6
9	1	1	1	2	2	7
10	3	1	2	3	2	11
11	1	1	3	2	2	9
12	2	1	2	2	2	9
13	2	1	1	1	1	6
14	1	1	3	1	1	7
15	1	1	2	1	1	6
16	2	1	2	1	1	7
17	2	1	2	1	2	8
18	1	1	3	2	2	9
19	4	1	3	1	1	10
20	1	2	3	3	2	11
21	4	2	1	2	1	10
22	2	1	3	3	2	11
23	2	1	3	2	2	10
24	1	2	2	2	2	10
25	2	1	3	2	2	10
26	2	1	1	2	1	7

HTM = hands to midline
HC = head centring
HRF = head righting - flexion
HRE = head righting - extension
AWBTS = active weight bearing through shoulders
TOTAL = total score

Ethical clearance All procedures were carried out in accordance with the requirements of the Ethics Committee of the University of South Australia.

Table 3. Total scores: Estimates of regression coefficients.

Variate	b_0	SE	*t*	*p*
(Constant)	26.17	2.80	9.35	
age	-0.927	0.169	-5.50	< 0.001
bath	-0.046	0.011	-4.09	< 0.001
exercise	-0.035	0.013	-2.75	< 0.05
capsule/cuddle	-0.009	0.003	-3.19	< 0.01

b_0 = regression coefficient
SE = standard error
t = estimate/standard error
p = significance

Results

Total score The infants' ages at assessment spanned an interval of four weeks. Age was highly significant (Table 3), increasing age of the infants across the sample being associated with a decrease in the subjects' total scores (indicating a more mature response). Significant associations were also shown between exercise, bath and capsule/cuddle and motor maturity of the upper limbs, trunk and head (Table 3). Such results indicate that increased time in these positions and activities was associated with enhanced motor skill development.

Item raw scores As discussed above, age was significantly correlated with the total score ($p < 0.001$). However, an examination of the significance of age in the individual item raw scores showed this variable to have the greatest association with the scores of the motor skills assessed in prone. Almost half of its effect was found in head righting (extension), where $b_0 = -0.422 \pm 0.070$.

Increased bath time was shown to be associated with the infants' improved performance of bringing their hands to midline ($b_0 = -0.017 \pm 0.008$, $p < 0.05$). Associations were also noted between score for hands to midline and time spent in the capsule/cuddle ($b_0 = -0.004 \pm 0.001$, $p < 0.05$), and exercise ($b_0 = -0.006 \pm 0.003$, $p < 0.05$). Increasing age was shown to be correlated with more mature head centring ($b_0 = -0.163 \pm 0.059$, $p < 0.05$), and time spent on the stomach was associated with a less mature score ($b_0 = 0.002 \pm 0.001$, $p < 0.05$). Prior to stepwise backward elimination, exercise was a significant coefficient in the analysis of head righting (flexion) ($b_0 = 0.021 \pm 0.009$, $p < 0.05$). Hence each minute spent experiencing exercise was associated with a more mature response when the infants were pulled to sit.

Regarding head righting (extension), the coefficient for age was large ($b_0 = -0.309 \pm 0.080$, $p < 0.001$), and highly significant; that is, the older subjects were associated with more mature head righting (extension). Increased time in the bath was also shown to be associated with more mature responses by subjects when lifting the head in prone ($b_0 = -0.018 \pm 0.006$, $p < 0.001$). The coefficient for age was the only one which showed a beneficial association with active weight bearing through shoulders ($b_0 = -0.233 \pm 0.081$, $p < 0.01$); older subjects achieved more mature scores. Conversely, the amount of time infants spent supine was associated with lesser ability to bear weight through the shoulders ($b_0 = 0.002 \pm 0.001$, $p < 0.05$).

Discussion

This study investigated the possible association between wakeful positional experience of four-month-old infants and their movement maturity. The null hypothesis, that there would be no significant difference due to such experience, was rejected for a few assessment parameters; that is, certain positional experience when the infant was awake was associated with more mature motor performance of particular tasks.

A difference in motor maturity between the younger and the older infants (as measured by the total score) was revealed, even though the variation in age was only four weeks. That greater age was associated with a more mature individual or summed motor response should not be interpreted as merely an effect of maturation. Although Gessell and Thompson (1929) and Dennis (1940) proposed that certain motor skills are determined by maturation alone, time provides opportunity for not only maturation, but also practice and motor learning. It was also implied by the same authors that prone motor skills were affected by the underlying processes involved in ageing to a greater degree than the other skills addressed in this study.

The positional categories which involved greater stimulation from, and closer interaction with, caregivers also produced significant coefficients. Over the three days, time spent exercising and experiencing bath and capsule/cuddle was associated with greater motor maturity. The indication in the present study that time spent in exercise was associated with enhanced motor responses of subjects is also supported by other studies which stress the importance of the environment in nervous system and musculoskeletal development (Greenough et al 1987, Nowakowski 1987, Wyke 1975), and motor skill acquisition (Hopkins and Westra 1988, Piper et al 1989, Razel 1988).

It was significant that the coefficient for bath was similar to that for exercise (Table 3), both being activities of similar type. Both involved closer interaction with an adult, more handling, greater stimulation and relatively more frequent position changes than other position classifications in this study. Consequently, the same mechanisms, whereby increased exercise was associated with more mature motor skills, may explain the association between bath and the same motor skills. Similarly, infants experiencing capsule/cuddle may have received considerable stimulation from the environment; being moved within the home, a moving vehicle or shopping trolleys, and interaction with the caregiver. Capsule use is extensive. They are commonly used as baby chairs and not just for the travel period; in this circumstance the infant is supported, with head and shoulders slightly raised in supine, a position suited to practice of eye-hand co-ordination and interaction with the environment. As information concerning the extent of movement and stimulation that the subjects were experiencing while in the capsule/cuddle position was not requested, further hypotheses are not possible.

Positions of greater stimulation were associated with increased ability in a number of test categories. During bath and exercise time, an observable increase in activity of an infant's limbs may occur. We propose that this activity increase may have improved infants' upper limb strength, or motor ability involving the arms, which could be transferred to other situations. More specifically, capsule/cuddle by definition involved time spent in supported supine position - a position ideal for practising bringing the hands together, and associated with a greater score of this ability. Alternatively, (as discussed for the total score), the generalised beneficial effects of experience in a stimulating environment such as bath, exercise and capsule/cuddle may have manifested as greater motor skill.

The association between score of head righting (flexion) and exercise was interesting, although fluctuant (significant before stepwise backward elimination but not after stepwise backward elimination). Some mothers specifically classified times spent in the "other" position as exercise time. These mothers often volunteered the information that pull-to-sit was part of the exercise time. Data concerning the infants' past experiences of pull-to-sit was not collected formally but may have been useful in attempting to determine the exact association between practice and motor performance.

Time spent on the back and in side lying was negatively associated with the subjects' maturity of response when propping through the elbows. It is possible that during supine or side lying time, neither prone experience nor possible prone motor skills were being gained. Conversely, greater time spent on the stomach was associated with lesser skill in the supine item head centring, supporting a similar hypothesis that during time spent prone, neither supine experience nor possible supine motor skills were gained.

With the potential that greater age was associated with more mature motor performance, it is possible that older infants were more able to participate in activities of parental interaction. Consequently, greater physical ability may lead to parents choosing activities of greater interaction, which in turn allows more practice, which may further facilitate performance. Clinically, it may therefore be possible that smaller, frail, or disabled infants, with less ability to participate in interactive activities, may be further disadvantaged in developing abilities in those positions.

Clinical experience suggests that infants who have experienced particular positions may score better in those positions. However, in this study specific positional experience was not associated with more mature motor responses in respective positions.

Conclusions

In seeking to find a relationship between wakeful

positioning and infant motor maturity, time spent in stimulating circumstances was shown to be associated with greater upper body motor development as measured by selected items from the MAI.

Whilst one prone motor ability (weight bearing through the shoulders) was negatively associated with time spent supine and side lying, and one supine ability (head centring) negatively associated with time spent prone, the results of this study did not show a more direct association between time spent prone and supine, and motor skills, in those positions.

Due to the small sample size, and the necessity for this project to create and use a new measuring tool (the log book), this must be regarded as a pilot study. Future research could be directed at a longitudinal study to examine the long-term effects of positioning differences of infants prior to four months of age. Furthermore, other issues, such as decreasing the variation of infant age at their time of testing, examining biological make-up, and ascertaining parental perception of their child's strength and the implications of these perceptions on infant positioning, could be further considered. A second assessment at a later date could examine whether motor maturity remained evident, or whether early differences no longer existed when the infants were older.

A subsequent similar study could consider only time spent in the four positions which were significant in this study. As this logging procedure would be less demanding, parents could be asked to log the time spent in the four positions over six days rather than three, and seek information concerning the amount of stimulation subjects are receiving while in the positions logged.

Information concerning the amount of stimulation the infants received was not requested as part of the logging procedure. As the positions which were associated with more mature motor development were those with increased intrinsic stimulation, the extent of interaction each infant was obtaining in other positions may have been useful information. Whilst information regarding the degree of stimulation may have allowed further analysis of the data, the extra logging required would have made the task more arduous for the parents, possibly jeopardising reliability.

It is possible that the sleeping position of the infant (whether during the logging time or during evening hours) may significantly impact on skill level or wakeful positioning choices. A modification of the logging procedure to record what sleeping position the infant uses predominantly might highlight an interesting and potentially strong relationship.

This pilot study investigated the possibility that associations existed between maturity of movement control and wakeful positioning of the infant. Trends emerged regarding certain positions or activities warranting further investigation. A causative relationship cannot be inferred from our data. A controlled randomised clinical intervention study with greater subject numbers would be more likely to elicit results with greater significance. Greater subject numbers would also help to minimise the likelihood of a Type 2 statistical error due to the relatively wide age window (both gestational and chronological).

It is possible that, if a causative relationship is sought in future studies, it could be found in either direction. In other words, an infant may prefer wakeful positions which enable it to use its strongest motor skills, and cry to be released from other positions - thus training its parent into selecting certain positions. It is equally possible that an infant may hone those motor skills which are best able to be practised in the wakeful positions imposed on it by its parents.

Longitudinal studies of the motor control of matched cohorts of infants experiencing various positioning routines would reveal whether any early differences in motor skill persist throughout childhood, and whether such differences are linked to wakeful positioning. This information would be welcomed by parents and carers eager to maximise their infants' motor development.

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